Heterogeneous Component Model for Architecture of Community Medical Internet of Things

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Abstract. As a kind of medical services around people, community health care is closely related to people's lives, and thus it has also been placed higher requirements. In the face of growing community medical needs, the construction and development of community medical Internet of things is imminent. Through analyzing the existing construction of medical Internet of Things, combined with the community application environment, a heterogeneous component model for the community medical Internet of things is designed to be applied to the actual community situation. The model includes three parts such as heterogeneous components for medical Internet of things, their flat physical structure and hierarchical logical structure. Related model description is presented meanwhile to make the whole system architecture more perfect and also make the system architecture meet the needs of different users.

Keywords: Community health · Internet of things · Component · Heterogeneity · Model

1 Introduction

As a basic unit of society, community is a group of life which is formed in a certain field by several social groups and social organizations. Therefore, to strengthen the quality of community health service is an important part of health care reform. Community health is the most front end of the entire health system. Establishing community personal health records, analyzing health status and health risk factors, establishing community health self-detection mechanism, the formulation of corresponding health care plan, providing personalized health services, strengthening community medical institutions with the hospital, reducing the risk of community members, and alleviating the pressure of large hospitals are the main contents of community health services.

In community medical Internet of things (CMIoT), some Internet of things technologies are used. In CMIoT, the general practitioners are taken as the backbone, focusing on the health of community residents, mainly for the elderly, children, women, patients with chronic diseases and disabilities, etc., its main tasks are disease prevention, health

F. Chen and Y. Luo (Eds.): Industrial IoT 2017, LNICST 202, pp. 140–151, 2017.
DOI: 10.1007/978-3-319-60753-5_15

care and medical services, and its main content is the treatment and rehabilitation of the common diseases, mild symptoms and chronic.

Using various means of communication and the Internet of things (IoT) technology to achieve multi-level contact among large medical institutions - community medical institutions - community masses, improving the circulation speed and real-time performance of health information, this will not only save medical resources, but also enhance the quality of service in the medical industry.

No matter that the CMIoT application system is mixed with heterogeneous components or oriented to information processing, when the system is complex to a certain extent, if we disign it with directly programming, it will increase the likelihood of errors or even failures.

In view of the complex collaborative design task of different components of CMIoT, in order to meet the requirements of good performance, low cost and high reliability, and improve the quality and efficiency of the system development, the design needs to be carried out under the description for completing the design cycle [1], and therefore, the first step in collaborative design of all kinds of components should be to establish the model of the system, that is to say, to get the abstract description of the system.

2 Related Works

Since the emergence of the IoT, many scholars and research institutions have designed the architecture of the Internet of things according to their characteristics, and for the specific application domain, a lot of reference architectures for building the Internet of things have been put forward. Chen [2] pointed out that up to now, no one has made a unified comparison and analysis of many Internet of things architectures, no one has a hierarchical induction of its implementation method, and no one correspond the system structure to the implementation method, all those make it difficult for designers to choose what kind of architecture and implementation method in the development of the Internet of things. In his paper, the analysis of the system structure and implementation methods of the predecessors is very thorough. However it is still based on the abstract level, and it is lack of a practical model. At present, many scholars have carried on the related researches on the system structure of the Internet of things and also proposed some architectures, e.g., World Wide Web Architecture of things (WOT) [3], IoT autonomic architecture, EPC network architecture [4], Architecture based on Wireless Sensor Networks (WSN), M2 M (machine-to-machine) architecture [5].

Many scholars build up the hierarchy of the Internet of things from the vertical perspective, e.g., the USN [6] (5 layers including the sensing, access, network infrastructure, middleware, and application platform layer) of International Telecommunications Union (ITU), Physical-net [7] (4 layers including service provider, gateway, coordination, and application layer), OT-A [8] (4 layers including application, IP, API M2 M, and wireless communication protocol layer), SENSEI [9] (3 layers including communication services, resources, applications layer), Networked Auto-ID [10] (3 layers including RFID identification and reading, information transmission network and identity analysis and services layer), uIDIoT [11], M2 M [12] (3 layers including the core network, service capabilities and application layer), AOA [13] (4 layers including data, passive intelligence, knowledge and management layer), SOA [14] (4 layers including sensing, network, service and interface). Ma [15] sets up a model of 4 layers of IoT architecture, which is composed of object layer, data exchange layer, information integration layer and application service layer, and abstracts the Internet of things from the functional level. It has better scalability and mobility, and has better adaptability in the large-scale and dynamic characteristics of IoT. However, how to achieve the specific implementation of structured protocol package is still a problem.

However, most of the existing IoT application systems are based on different protocols and mechanisms. Their composition has strong heterogeneity used in different industries and fields. Therefore, it is needed to build the flat IoT architecture so as to solve the problem of mutual connection and communication between different components. Xie [16] proposes a physical model driven software architecture of IoT, composed of 3 layers such as application model, the sensing/executing model and the physical model, in which vertical physical applications are interconnected in a unified framework and implementation method and the architecture of the proposed IoT is verified with Wright and other methods of formal description and proof. But it does not take into account the interaction between social groups in the user model and the factors that affect the overall stability of the model. IoT-A model unifies the different wireless communication protocol stack as a material communication interface, combine the interconnection communication protocol to support the interconnection between large scale and heterogeneous devices, and support a large number of different components and their applications without specific scheme in the support of behavior model.

In the specific application, Cao [17] proposes the architecture of information system for the smart grid development from the perspective of information technology, including 3 layers such as the infrastructure layer, platform layer, and application layer. It realizes the integration and interaction of physics, information and application system. Since the structure is designed for smart grid, it lacks the extensible support for the heterogeneous components of the IoT applications. From the trend of the integration of human and vehicle, and the coordination needs of human, vehicle and environment, for vehicle networking, Li [18] proposes the object collaboration model and the architecture model, so that these models can meet the requirements of global information sensing, control and sustainability of vehicle networking services. However, because the structure is very high to the multi dimension group collaborative computing and evaluation, there are still some needs to study new theories and models to support it.

3 Heterogeneous Components in CMIoT

Component technology is a new idea of software development, in which the complex large-scale system is decomposed into several independent modules, and a unified connection standard between the components is established, in order to realize the connection between components or between components and users. Component technology packages details which users can operate directly without needing to fully understand. The research of component technology makes the process of system development have a very big change, at the same time, the maintenance cost of the system is greatly reduced, the flexibility of the development is increased, and the most important is that it can greatly enhance the scalability of the system. Therefore, we introduce the design idea of the component to the architecture of CMIoT. In the heterogeneous component model of CMIoT, a variety of different functional entities in the community medical Internet of things are abstracted into some objects with independent attributes and methods, and then, according to the different needs of each application, designers select the desired object so that objects can work together, and ultimately achieve the desired function.

3.1 Heterogeneity of Components in CMIoT

It is mainly manifested as follow:

– **Heterogeneity of network transmission**
  It shows the diversity of transmission modes. Data or control commands in the transmission process, possibly reach the destination through different networks. Common network transmission modes include 2G/3G/4G and other mobile communication networks, wireless sensor networks, wireless local area networks and large-scale data transmission network.
– **Heterogeneity of component functionality**
  It shows that each component has a different job content. In IoT, the functionalities of the components are usually divided into data acquisition, data transmission, data processing and data services. Each component achieves its respective functions and all components work together.
– **Heterogeneity of component behavior**
  It shows different information processing methods of different components. For the components of the hardware modules, they process signal information, and for the components of the software modules, they process data information.
– **Heterogeneity of component structure**
  It shows that different components have different internal structures and there are different connection structures between components. For the sensing/executive component, it mainly consists of the sensing or executive module. For the data processing component, it mainly consists of data processing module.

3.2 Composition of Components in CMIoT

According to the functionalities of CMIoT, it can be divided into the following several major components.

– **Sensing components**
  They are sensing nodes in CMIoT. Their functions are different, and they are used to sense various physical sign data and environmental data. They are to help users to collect their own physiological parameters, and monitor their health status.
– **Executive components**

They are executer nodes in CMIoT. Their role is to receive the decision information which is determined by the analysis of the computing component, and to act on the decision.

– **Computing (information integration) components**
  They include two kinds such as microprocessors with the computing function and the related equipment and health care workers who participant in medical activities.
– **Transmission components**
  They are a kind of components with information transfer functionalities. They include Wi-Fi, ZigBee, 3G, 4G, and wired Ethernet, etc.
– **Storage components.**
  They are the storage containers for system information. They are embodied in the sensing components, executive components, computing components, etc.

4 Flat Physical Structure of CMIoT

A big difference between IoT and Internet is that the members of the Internet of things are the objects in reality, not the abstract concept. Therefore, according to the application environment of CMIoT, its physical structure of the component model needs to be given. This structure is flat in intuition. It is divided according to the space region and role in CMIoT. It mainly includes community resident unit, community care unit and medical support unit. Through this structure, as shown in Fig. 1, we can clearly understand the physical composition of CMIoT and the interaction between the constituent elements.

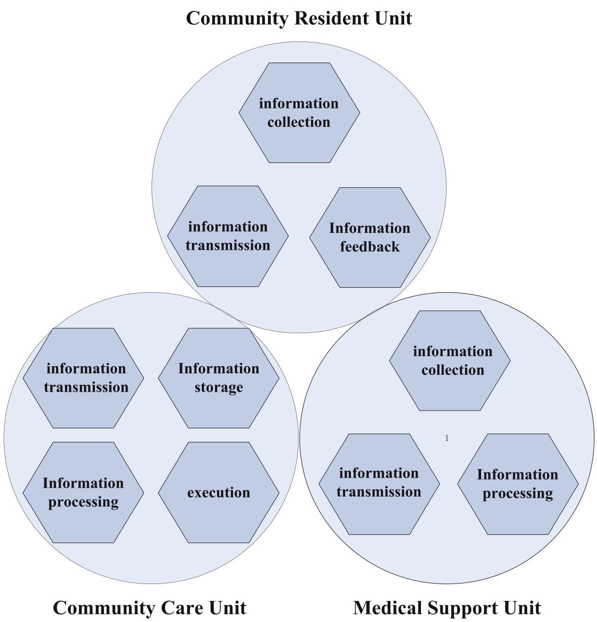

Fig. 1. Physical structure of CMIoT.

4.1 Community Resident Unit

In CMIoT, all sources of information at the beginning are community resident units, which constitute the most front ends of the whole physical structure, and usually contain information collection part, information transmission part and information feedback part.

4.2 Community Care Unit

It is the data processing and decision making unit of the whole physical system and at the same time is also the executive unit of the decision-making unit, and constitutes the back-end of the physical structure. Its composition includes information transmission part, information storage part, information processing decision part and executive part.

4.3 Medical Support Unit

Although the community medical unit has certain medical decision-making ability and is also capable of providing medical care for mild conditions and known chronic diseases, when faced with a serious illness, its ability is slightly less. At this point, the community medical unit will be able to turn to the medical support unit (generally refers to large medical institutions) for help. The medical support unit mainly includes information transmission part information processing decision part and executive part.

5 Hierarchical Logical Structure of CMIoT

In addition to the division according to the space region and role, designers can also be to establish the hierarchical model of the heterogeneous components of CMIoT in accordance with the logic level of components. As shown in Fig. 2, it mainly consists of four layers: sensing/executing layer, data transmission layer, information integration layer and application system layer.

5.1 Sensing/Executing Layer

Sensing/executing layer is divided into two sub layers such as physical sub layer and device sub layer. The physical sub layer is composed of some physical components, e.g., machine, house, electric appliance, vehicle, watch, even air or human body, etc., which are composition elements of the physical environment, and used to receive some controlling signals from controllers and send feedback signals to sensors. The device sub layer includes some device components connected with physical components so as to make the latter run in more smart way.

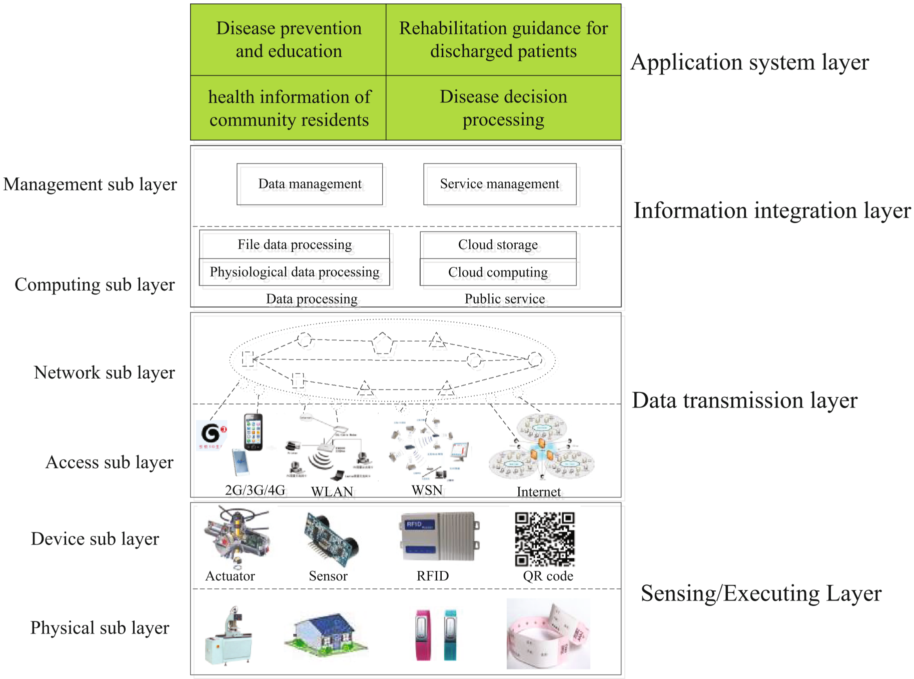

Fig. 2. Hierarchical logic structure of CMIoT.

5.2 Data Transmission Layer

This layer is the connection and information transfer layer of CMIoT. The main task is to build a bridge for the sensing/executing layer and the information integrated layer and transfer information between them. This layer can also be divided into two sub layers including access sub layer and network sub layer. The access sub layer contains a variety of access components such as 2G/3G/4G/5G, IEEE 801.11, IEEE 802.3, ZigBee, Bluetooth, infrared and so on. The network sub layer is used to establish the connection of heterogeneous network, e.g., IPv6 is the most suitable choice for the future.

5.3 Information Integration Layer

The information integration layer is a middleware layer which provides common service components for the system application layer. It includes computing sub layer and management sub layer. For the computing sub layer in CMIoT, there is a kind of public service components such as cloud storage, cloud computing, and also there is a kind of data processing components such as physiological data processing, file data processing (sorting, computing, etc.), encryption/decryption, and so on. For these two kinds of components, in the information integration layer, their management components are provided in the management sub layer so that the latter can manage them.

5.4 Application System Layer

CMIoT takes the health of community residents as the central service. The main service objects are the elderly, children, women, patients with chronic diseases and disabilities, etc. Its main task is disease prevention, health care, medical treatment, and so on. The main content is the treatment and rehabilitation of common diseases, mild symptoms and chronic diseases. Therefore, this layer should include the following contents such as disease prevention and education, health information of common residents, rehabilitation guidance for discharged patients, and disease decision processing.

5.5 Model Description

In order to facilitate the visual description of the heterogeneous component model of CMIoT, some graphic elements are introduced as shown in Fig. 3. The rectangle represents a component, and its interior is composed of attributes and behaviors. The triangle represents an interface connected different components. The line indicates the direction of information transfer.

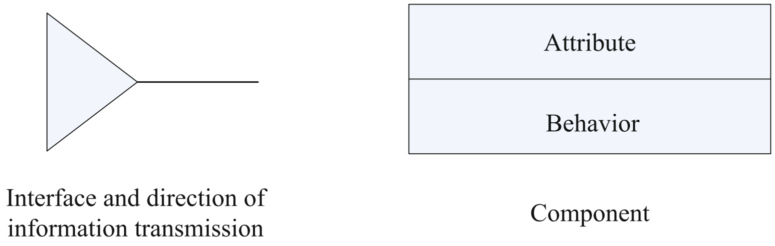

Fig. 3. Component graphics.

Through the analysis of flat physical structure and hierarchical logical structure of CMIoT, its model is built as shown in Fig. 4. The whole model consists of user component, sensing component, transmission component, storage component, computing component and so on which form a closed loop. In this model, first, the sensing component senses the monitoring data from the user side, and is uploaded to the storage component through the transmission component. Second, the data is saved by the storage component. Third, the computing component can extract the relevant information from the storage components, and through the method of data mining, cloud computing and artificial identification, the information is processed and fused, and the decision information is generated. Finally, the decision information is transmitted to the executing component through the transmission component, and finally the user component is affected.

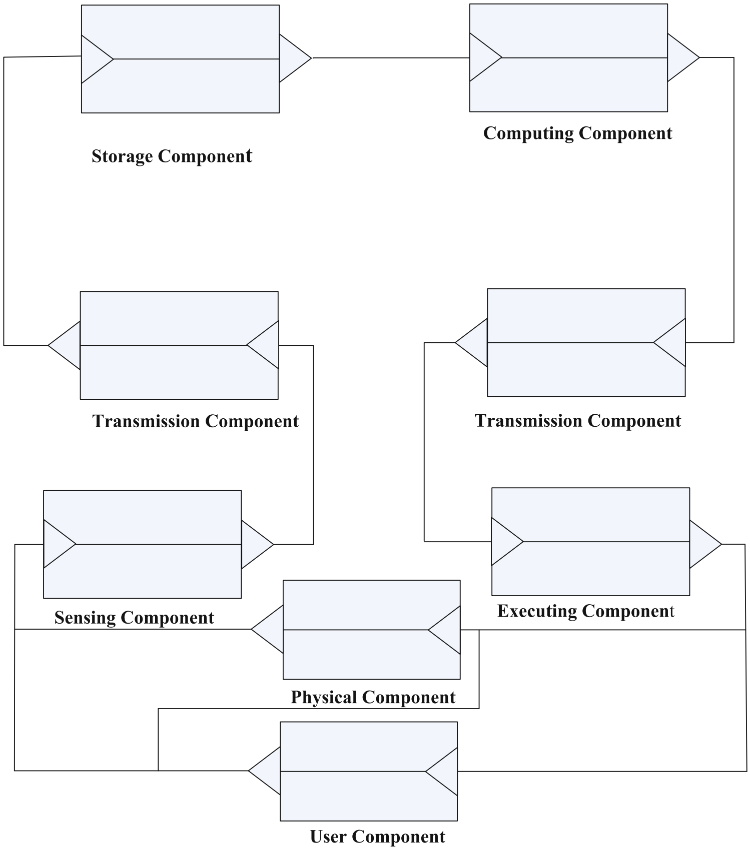

Fig. 4. Model of heterogeneous components.

6 Prototype System of CMIoT

6.1 Network Structure

In the prototype System of CMIoT, the transmission part adopts ZigBee + Wi-Fi wireless transmission mode, and at the same time, wired Ethernet is taken as an auxiliary transmission mode. The network structure is shown in Fig. 5.

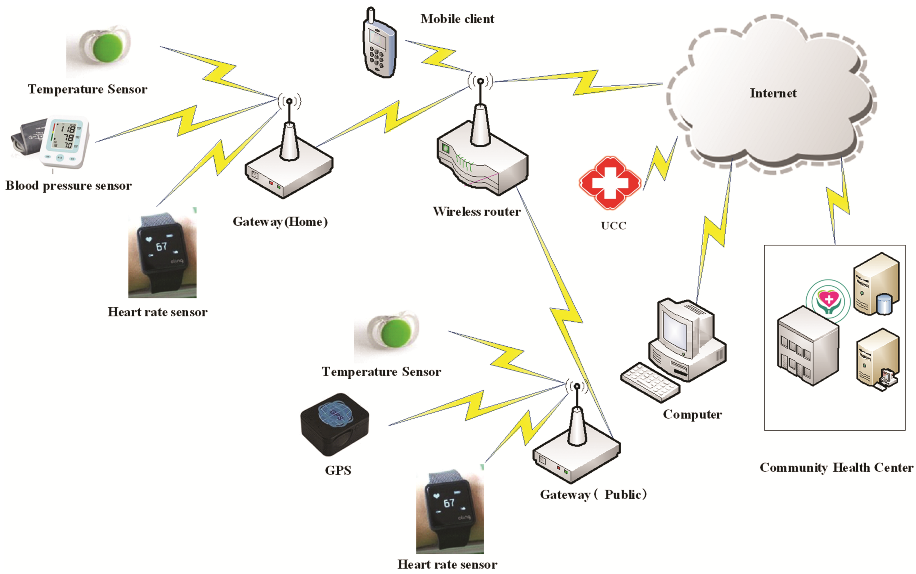

Fig. 5. Prototype system of CMIoT.

The transmission component of sensor and actuator side adopts the ZigBee transmission mode. A large number of ZigBee terminal nodes communicate with the gateway in their respective regions and form their own ZigBee network. The sink gateway of different regions is connected with the converged wireless router which is distributed in the fixed area through the Wi-Fi mode. Wireless router can choose wired or wireless way to connect to the Internet network. According to the actual situation, computing components select the apt access network, and due to the high requirements of data transmission speed and stability, storage components (data server) adopt wired access mode.

6.2 Deployment Structure

The whole prototype system is divided into three blocks, which are three different areas such as home, public area and community hospital as shown in Fig. 6. Among them, in the home, there is a sink gateway and two sensing/executing nodes, in which the sensing component is a temperature sensor for measuring the temperature value of the user, the executing component is a buzzer connected with the sink gateway. The configuration of the public area is similar to the home. In the community hospital, there is a desktop as a storage component (which is the role of the system server), a laptop as a computing component (system client), and a wireless router as information transmission component.

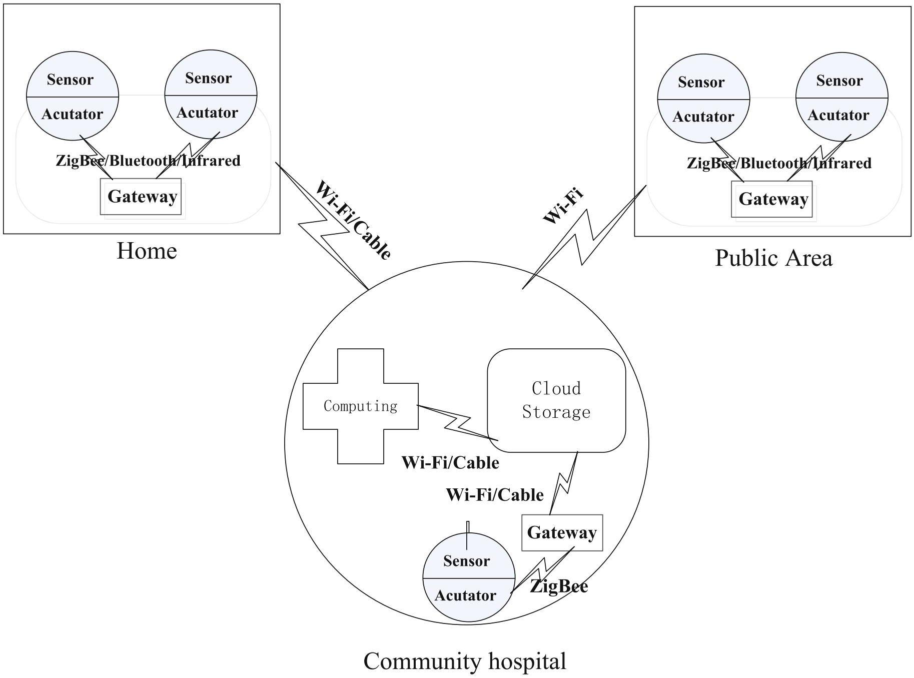

Fig. 6. Deployment structure diagram.

7 Conclusion

This paper takes CMIoT as a standpoint. We first analyzes the main tasks of community medical Internet of things, and based on these tasks and the actual situation of the community medical environment, a heterogeneous component model is proposed. The definition, composition, flat physical structure and hierarchical logical structure are given. The graphical description of the model is provided. All above lay the foundation for the next step to build a prototype system for CMIoT.

Acknowledgement. The authors would like to thank our colleagues and students in Engineering Technology Research Center of Network and Information Security at Anhui Normal University. We thank National Natural Science Foundation of China under Grant No. 61572036, University Natural Science Research Project of Anhui Province under Grant No. KJ2014A084, Anhui Province University Outstanding Youth Talent Support Program under Grant No. gxyqZD2016026 and Anhui Provincial Natural Science Foundation under Grant No. 1708085MF156.

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